CLAIMS

What is claimed is:

1. A method for forming a copper damascene feature comprising the steps of:

providing a semiconductor process wafer comprising at least one via opening formed to extend through a thickness of at least one dielectric insulating layer and an overlying trench line opening encompassing the at least one via opening to form a dual damascene opening;

etching through an etch stop layer at the at least one via opening bottom portion to expose an underlying copper area;

carrying out a sub-atmospheric DEGAS process with simultaneous heating of the process wafer in a hydrogen containing ambient;

carrying out an in-situ sputter-clean process; and,

forming a barrier layer in-situ to line the dual damascene opening.

2. The method of claim 1, further comprising the steps of:

forming a copper seed layer in-situ to line the dual damascene opening;

carrying out an electrochemical copper deposition process to fill the dual damascene opening with a copper layer; and,

carrying out a CMP process to remove the copper layer and the barrier layer above the trench level.

3. The method of claim 1, wherein the hydrogen containing ambient is provided at a pressure of about 1 mTorr to about 10 Torr and a hydrogen gas concentration of about 1% to about 20% with a remaining portion consisting essentially of inert gas.

4. The method of claim 3, wherein the hydrogen containing ambient is provided at a pressure of about 1 mTorr to about 100 mTorr.

5. The method of claim 1, wherein the hydrogen containing ambient comprises a hydrogen concentration from about 3 % to about 10 %.

6. The method of claim 1, wherein the a sub-atmospheric DEGAS process is carried out at a temperature between about 100 °C and about 500 °C.

7. The method of claim 1, wherein the a sub-atmospheric DEGAS process is carried out at a temperature between about 250 °C and about 450 °C.

8. The method of claim 1, wherein the sub-atmospheric DEGAS process is carried out for a period of between about 20 seconds and about 120 seconds.

9. The method of claim 1, wherein the barrier layer comprises at least one layer selected from the group consisting of refractory metals, refractory metal nitrides, and silicided refractory metal nitrides.

10. The method of claim 9, wherein the barrier layer comprises at least one layer selected from the group consisting of Ta, Ti, TaN, TiN, TaSiN, and TiSiN.

11. The method of claim 1, wherein the sputter-clean process comprises hydrogen gas.

12. A method for forming a copper damascene features in low-K a porous dielectric insulating layers comprising the steps of:

providing a semiconductor process wafer comprising at least one via opening formed to extend through a thickness of at least one inorganic low-K dielectric insulating layer and an overlying trench line opening encompassing the at least one via opening to form a dual damascene opening;

etching through an etch stop layer at the at least one via opening bottom portion to expose an underlying copper area;

carrying out in-situ a sub-atmospheric DEGAS process with simultaneous heating of the process wafer in a hydrogen containing ambient;

carrying out an in-situ sputter-clean process comprising hydrogen gas; and,

forming a barrier layer in-situ to line the dual damascene opening.

13. The method of claim 12, further comprising the steps of:

forming a copper seed layer in-situ to line the dual damascene opening;

carrying out an electrochemical copper deposition process to fill the dual damascene opening with a copper layer; and,

carrying out a CMP process to remove the copper layer and the barrier layer above the trench level.

14. The method of claim 1, wherein the hydrogen containing ambient is provided at a pressure of about 1 mTorr to about 10 Torr and a hydrogen gas concentration of about 1% to about 20% with a remaining portion consisting essentially of inert gas.

15. The method of claim 3, wherein the hydrogen containing ambient is provided at a pressure of about 1 mTorr to about 100 mTorr.

16. The method of claim 1, wherein the hydrogen containing ambient comprises a hydrogen concentration from about 3 % to about 10 %.

17. The method of claim 1, wherein the a sub-atmospheric DEGAS process is carried out at a temperature between about 100 °C and about 500 °C.

18. The method of claim 1, wherein the a sub-atmospheric DEGAS process is carried out at a temperature between about 250 °C and about 450 °C.

19. The method of claim 1, wherein the sub-atmospheric DEGAS process is carried out for a period of between about 20 seconds and about 120 seconds.

20. The method of claim 9, wherein the barrier layer comprises at least one layer selected from the group consisting of Ta, Ti, TaN, TiN, TaSiN, and TiSiN.